Impact of Extremity Amputation on Combat Wounded Undergoing Exploratory Laparotomy

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Background: Combat casualties with traumatic amputations (TA) and requiring laparotomy present unique clinical challenges. The purpose of this study was to determine the association of TA on blood/blood product usage, emergency department (ED) and operating room (OR) times, and mortality in those undergoing exploratory laparotomy after combat injury.

Methods: A retrospective study was performed at one combat support hospital in Iraq of patients requiring exploratory laparotomy for abdominal injury. These patients were divided into two cohorts based on the presence or absence of TA. Initial vital signs, international normalization ratio, pH, blood product usage, time in ED and OR, and mortality were compared between groups.

Results: We reviewed 171 consecutive laparotomies performed between September 2007 and May 2008. Twenty one were identified with TA. Presenting systolic pressure, hemoglobin, platelets, international normalization ratio, and arterial pH did not differ between groups. The TA group presented more tachycardic, received more blood/blood products in ED and OR, and were more likely to meet requirements of massive transfusion. There was no difference in mortality between groups. Time in ED was shorter and time in OR was longer for the TA cohort.

Conclusion: TA with penetrating abdominal injuries are associated with increased transfusions of blood products beginning at patient arrival. Massive transfusion protocols should be activated as soon as this injury is identified. The severity of this injury pattern was only manifested by an increased heart rate at admission. TA with abdominal injury spent less time in ED and a longer time in OR; however, there was no increase in mortality.

Key Words: Trauma, Combat wounds, Amputations, Hemorrhage, Massive transfusion, Time, Iraq, OIF.

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The majority of deaths on the modern battlefield are nonsurvivable.[1] Of those deaths deemed potentially preventable, extremity hemorrhage is a leading cause of mortality.[1–5] Prevention of exsanguination is dependent on recognition, and rapid control of bleeding and transport to level of definitive care where blood/blood products can then be transfused and surgical control of bleeding be obtained.

During Operation Iraqi Freedom (OIF), injuries sustained by coalition forces have increased not only in severity but also in number in the same casualty.[5] This represents a shift from conventional war to an "asymmetric" battlefield with increased use and sophistication of improvised explosive devices (IEDs) and other explosive devices. It is now commonplace for a casualty to have not only multiple injuries in separate body regions but also multiple injuries within the same body region (i.e., chest and abdomen or bilateral lower extremities).[1,5]

The purpose of this study was to determine the impact of traumatic extremity amputation on those undergoing exploratory laparotomy for abdominal injury. Specifically, how this constellation of injuries affected blood/blood product usage, time in emergency department (ED) and operating room (OR), and overall mortality.

METHODS

An Institutional Review Board approved retrospective review of all patients treated at a single combat support hospital (CSH) in Iraq between 28 September 2007 and 05 May 2008. Data were obtained from on-site at the CSH, the Joint Theater Trauma Registry (JTTR) maintained at the US Army Institute of Surgical Research, and the Joint Patient Tracking Application. The JTTR is a department of defense database established to prospectively collect data from multiple clinical and administrative systems. The Joint Patient Tracking Application is a department of defense application to record a patient's progress from the battlefield through recovery or death. A retrospective cohort analysis was performed of 171 consecutive patients who required an exploratory laparotomy for abdominal injury. These patients were divided into two cohorts according to the presence or absence of traumatic amputation (TA).

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Demographic, laboratory, and physiologic data, as well as transfusion requirements and outcomes were obtained. Blood transfusions consisted of packed RBCs (pRBCs), fresh whole blood (WB), or a combination of both. Transfusion requirements were obtained from the JTTR, and massive transfusion (MT) was defined as ≥10 units of blood in the initial 24 hours after admission. Patients were excluded from the study if they did not have an exploratory laparotomy for abdominal injury. Additional exclusion criteria were treatment at another medical facility before transfer to the CSH, age younger than 18 years, or designation as a security internee.

Data compiled for analysis included source of injury (i.e., gun shot wound, IED, motor vehicle collision), time of admission, time exploratory laparotomy started and finished, admission vital signs (VS), admission laboratories, Military Injury Severity Scores (MilISS), and mortality. Additionally, transfusion (pRBC, fresh frozen plasma [FFP], WB) and fluid (crystalloid and colloid) requirements during the first 24 hours after admission were obtained. VS and laboratories taken at admission were hemoglobin (Hgb), platelets (Plt), base deficit, International Normalization Ratio (INR), and temperature. Recorded VS and compiled laboratory results were the earliest available after admission. Blood values were measured using standard clinical chemistry techniques. Additional data obtained at admission were tourniquet use, presence of head injury, and extremity injury. Total transfusion requirements in the first 24 hours after admission included all blood components (units of pRBCs, FFP, and WB). WB was calculated as 1 unit plasma and 1 unit pRBC. Cumulative pRBC:FFP ratios were calculated at three different time points, ED, OR, and at the end of the first 24 hours. Mortality was also compared among the two cohorts. We also compared time ED and OR between these groups. Additionally, total factor VIIa use during the initial 24 hours after admission was obtained. The MilISS were calculated from patients medical records according to the published guidelines of Baker et al.[6]

Continuous variables were compared with a Student's t test or Wilcoxons test and categorical variables were described with χ^2 analysis using SPSS 16.0 (Cary, NC). Microsoft Office Excel 2003 (Microsoft Corp., Redmond, WA) was used for database construction. Variables are expressed as mean ± SD, and statistical significance was set for a $p < 0.05$ unless otherwise noted.

RESULTS

One hundred seventy-one consecutive laparotomies performed between 28 September 2007 and 05 May 2008 were reviewed. VS and laboratory data of the patient population are presented in Table 1.

There was no difference in TA between coalition forces and civilians. Twenty one of the 171 (12%) were identified as having a TA. A tourniquet had been placed on 12 of 17 (71%) TA patients, whose charts were available for review, in the field before arrival at the CSH. The TA group had a higher MilISS (35 ± 15.4 vs. 18 ± 13.2, $p < 0.001$), presented with more tachycardia (128 ± 26 vs. 109 ± 32, $p < 0.05$), was transfused more total pRBC (17.2 ± 12.2 vs. 8.6 ± 11.7, $p < 0.05$), total FFP (13.1 ± 9.6 vs. 6.8 ± 10.1, $p < 0.05$), six packs of platelets (3.0 ± 8.4 vs. 0.9 ± 2.6, $p < 0.05$), a shorter time from admission to beginning of the exploratory laparotomy (48minute ± 33 minute vs. 92 minute ± 104 minute, $p < 0.05$), and a longer time in OR (164 minute ± 97 minute vs. 121 minute ± 78 minute, $p < 0.05$) compared with the non-TA group (Table 2, Fig. 1). The mechanism of injury of 18 of 21 (85%) patients in the TA group was IED (Table 3).

Those patients with TA required more pRBC and FFP in the ED and OR (4.8 ± 3.3 vs. 2.1 ± 3.0, $p = 0.001$; 2.5 ± 1.8 vs. 1.1 ± 1.6, $p < 0.001$; 10.0 ± 9.5 vs. 4.8 ± 7.8, $p = 0.002$; 8.7 ± 7.4 vs. 4.3 ± 7.3, $p = 0.002$; respectively) than those patients without TA. The TA patients also required more pRBC after OR (2.4 ± 3.0 vs. 1.7 ± 4.3, $p = 0.016$). There was no difference in crystalloid or colloid use between TA and non-TA cohorts (3.1 ± 2.5 L vs. 2.4 ± 1.7 L and 0.28 ± 0.32 L vs. 0.29 ± 0.29 L, respectively) (Table 4, Fig. 2).

The pRBC:FFP ratios at three different time points were calculated; in the ED, OR, and overall for the first 24 hours. The TA group received a higher ratio in the ED and in the OR than the non-TA group (1.6 ± 1.2 vs. 0.8 ± 1.0, $p = 0.002$; 1.3 ± 1.0 vs. 0.8 ± 0.8, $p = 0.036$, respectively). However, there was no difference in the ratio between the two cohorts

Table 1 Patient Variables

Demographics	
Age	27.3 ± 16.1
Coalition vs. civilian (%)	32 vs. 0.5
Male vs. female (%)	87 vs. 0.3
Vital signs	
SBP (mm Hg)	115 ± 31.4
Pulse (bpm)	112 ± 31.8
Respiration rate (per min)	26 ± 14.2
GCS	13.2 ± 3.8
Temperature (F)	97.9 ± 7.6
Military ISS	21 ± 14.8
Laboratory data	
Hgb (g/dL)	12 ± 2.9
Plt (10^3 cells/mm^3)	262 ± 129.0
INR	1.4 ± 0.8
Base deficit (mEq/L)	−5.3 ± 5.6
pH	7.28 ± 0.1
Blood products	
Total pRBC (units)	9.65 ± 12.1
FFP (units)	14.3 ± 88.1
Platelets (6 packs)	1.17 ± 3.8
Fluid administration	
Crystalloid (mL)	2499 ± 1852.9
Colloid (mL)	267 ± 287.4
Times	
Admission to OR time (min)	86.9 ± 99.0
Operating room time (min)	126 ± 80.8

The means and standard deviations for the parameters.

Table 2 The Patient Population was Split into Two Groups Based on Traumatic Amputation (TA)

	TA	Non-TA
Demographics		
Age	24.1 ± 10.5	27.8 ± 16.8
Coalition vs. civilian (%)	48 vs. 52	31 vs. 69
Male vs. female (%)	90 vs. 10	86 vs. 14
Vital signs		
SBP (mm Hg)	111 ± 42	115 ± 30
Pulse (bpm)*	128 ± 26	109 ± 32
Respiration Rate (per min)	26 ± 8.6	26 ± 14.9
GCS	12.9 ± 3.8	13.2 ± 3.9
Temperature (F)	93.2 ± 18.2	98.3 ± 5.7
Military ISS*	35.0 ± 15.4	18.0 ± 13.2
Laboratory data		
Hgb (g/dL)	11.3 ± 2.7	12.1 ± 3.0
Plt (10^3 cells/mm^3	244 ± 112	265 ± 131
INR	1.5 ± 0.7	1.4 ± 0.8
Base deficit (mEq/L)	−6.3 ± 5.9	−5.2 ± 5.6
pH	7.3 ± 0.1	7.3 ± 0.1
Blood products		
Total pRBC (units)*	17.2 ± 12.2	8.6 ± 11.7
FFP (units)*	13.1 ± 9.6	6.8 ± 10.1
Platelets (6 packs)*	3.0 ± 8.4	0.9 ± 2.6
Fluid administration		
Crystalloid (mL)	3053 ± 2510	2422 ± 1740
Colloid (mL)	280 ± 315	265 ± 285
Times		
Admission to OR (min)*	48 ± 33	92 ± 104
Operating room (min)*	164 ± 97	121 ± 78

The means and standard deviations for the parameters were calculated following this division.

* Significantly different ($p < 0.05$) from non-TA.

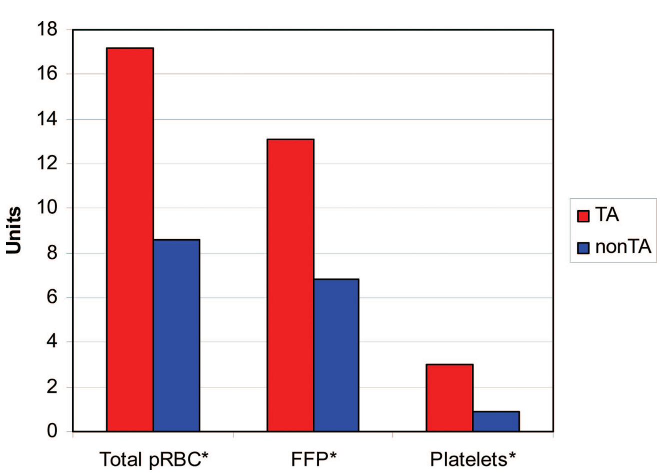

Fig. 1. *Comparison of total transfusions by cohort.* *p < 0.05.

overall (1.0 ± 0.6 vs. 0.9 ± 0.8, $p = 0.117$). Additionally, factor VIIa use was not statistically different between the two groups (0.5 ± 1.2 vs. 0.3 ± 1.1, $p = 0.216$) (Table 5).

The TA group had an increased risk of MT (76% vs. 34%, $p < 0.001$) compared with the non-TA group. Presence of extremity injury in the TA group was 100% versus 35% in the non-TA group ($p < 0.001$). Damage control surgery without primary closure was performed on 45% of the TA patients and 46% of the non-TA patients ($p = 1.00$). A concomitant head injury was identified in the 20% of the TA patients and 11% of the non-TA patients ($p = 0.261$). Mortality in the amputation group was 14% compared with 9% for the nonamputation group ($p = 0.421$) (Table 6, Fig. 3).

Table 3 Cohort by Mechanism of Injury

	TA (n = 21)	Non-TA (n = 150)
GSW	1 (5)	70 (47)
IED	18 (85)	56 (37)
Mortar/rocket	0 (0)	11 (7)
RPG/grenade	1 (5)	3 (2)
MVC	0 (0)	5 (3)
Fall	0 (0)	1 (1)
Crush	0 (0)	3 (2)
Burn	1 (5)	0 (0)
Assault	0 (0)	1 (1)

Values in parentheses are percentages.

Table 4 Transfusion and Fluid Requirements per Cohort

	TA	Non-TA	*p*
ED pRBC	4.8 ± 3.3	2.1 ± 3.0	0.001
ED FFP	2.5 ± 1.8	1.1 ± 1.6	0.000
OR pRBC	10.0 ± 9.5	4.8 ± 7.8	0.002
OR FFP	8.7 ± 7.4	4.3 ± 7.3	0.002
OR platelets	2.4 ± 7.8	0.6 ± 1.7	0.177
Post-OR pRBC	2.4 ± 3.0	1.7 ± 4.3	0.016
Post-OR FFP	1.8 ± 3.3	1.4 ± 4.0	0.171
Crystalloid (mL)	3053 ± 2510	2422 ± 1740	0.362
Colloid (mL)	280 ± 315	265 ± 285	0.980

The means and standard deviations for the parameters.

DISCUSSION

The primary finding of this study is that those combat casualties who present with both TA and penetrating abdominal injury were more likely to require MT (odds ratio, 6.21; CI, 2.2–17.9). Therefore, the blood bank should be notified and MT protocol should be activated as soon as this injury pattern is identified. In austere environments, resources such as WB may need to be quickly marshaled if available blood bank services will soon be overwhelmed.

The study population presented here is unique in that these patients present with simultaneous traumatic extremity amputation and abdominal injury requiring exploratory laparotomy. Ninety percent of the subjects in the TA cohort were injured by fragmenting munitions (1 from rocket propelled grenade and 18 from IED) with all but two having affected lower extremity(s). Only 46% of the cohorts without TA were injured by fragmenting munitions. IEDs are now produced with more explosive power that generate a larger fireball and have a wider wounding pattern causing worse fragmentation injury.[5] Despite the potential for life-threatening exsanguination, those with TA did not differ in presenting VS, with the exception of heart rate, or laboratory values such as Hgb, pH,

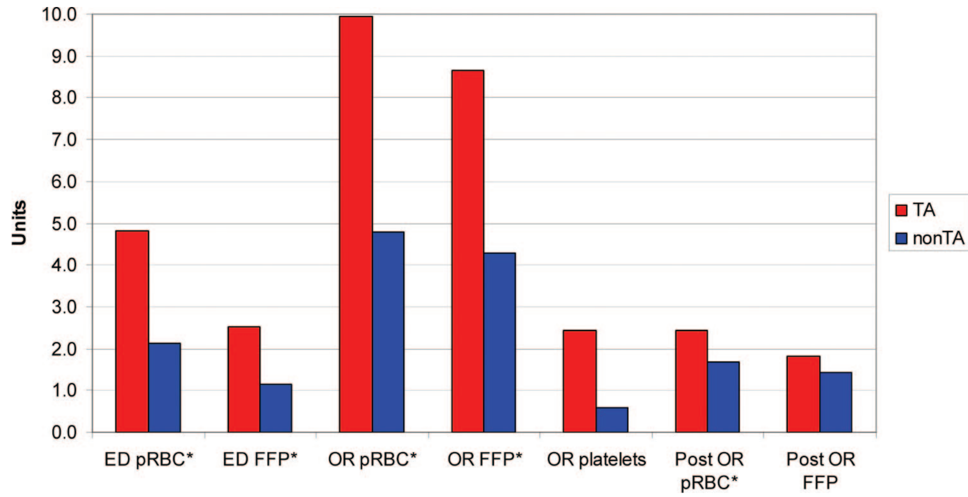

Fig. 2. *Comparison of transfusions by time in traumatic amputation (TA) and no traumatic amputation (non-TA). *p < 0.05.*

Table 5 pRBC:FFP Ratios

	TA	Non-TA	*p*
ED pPRBC:FFP	1.6 ± 1.2	0.8 ± 1.0	0.002
OR pRBC:FFP	1.3 ± 1.0	0.8 ± 0.8	0.036
Total pRBC:FFP	1.0 ± 0.6	0.9 ± 0.8	0.117
Factor VIIa	0.5 ± 1.2	0.3 ± 1.1	0.216

The means and standard deviations for the parameters.

Table 6 Dichotomous Variables

	TA	Non-TA	*p*
Massive transfusion	16/21 (76)	51/150 (34)	<0.001
Extremity injury	21/21 (100)	53/150 (35)	<0.001
Damage control	9/20 (45)	66/143 (46)	1
Head injury	4/20 (20)	16/150 (11)	0.261
Mortality	3/21 (14)	13/150 (9)	0.421

Values inside parentheses are percentages.

or INR when compared with those without extremity amputation. This may reflect the skill of the field medic in resuscitation and tourniquet use as well as a mature battlefield and current standard operating procedures used in the theater.[1] Tactical combat casualty care doctrine directs saline lock of all IVs as well as the use of small boluses of hetastarch to endpoints of resuscitation in improving mental status or restoration of radial pulse.[1,7,8] Although controversial, this hypotensive resuscitation should result in less blood loss during longer transportation times experienced by the military casualty compared with the civilian (42 minute vs. 13 minute)[1,8,9] as well as minimizing prehospital crystalloid resuscitation.

Hemorrhage from extremity injuries may be a preventable cause of death since casualties surviving to reach surgical treatment in the field will often have ongoing bleeding from the extremity.[1,8,10,11] This may be controlled by simple first aid maneuvers such as digital pressure, with or without hemostatic dressings, or tourniquet use during extrication and/or transportation to the level of definitive care (Fig. 4).[2,12] Of 17 TA patients whose charts were complete and available for review, 12 presented to the CSH with 13 working tourniquets in place (one subject had bilateral lower extremity TAs) while a 14th was placed immediately at patient arrival to trauma bay for hand amputation. Emergency tourniquet use has been shown to improve survival rates in those with major limb trauma while keeping morbidity risks low in this population.[3,4] This survival advantage then extends to the multiple-injured trauma patient.

Although Hgb, platelet count, and INR were not different between groups, those presenting with TA in addition to

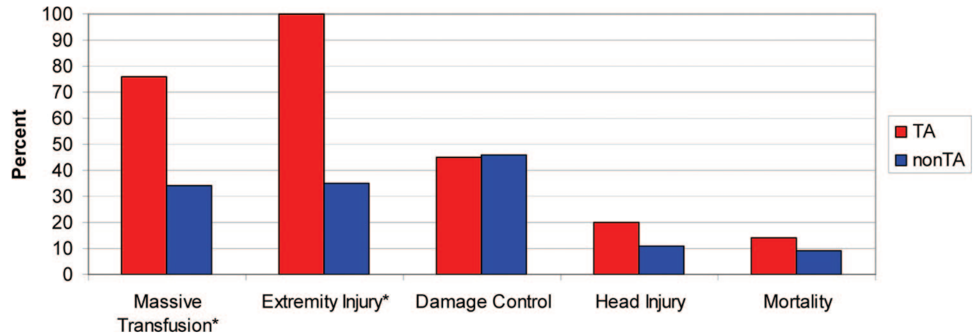

Fig. 3. *Comparison of dichotomous variables by cohort. *p < 0.05.*

Fig. 4. *Photograph demonstrating tourniquet use after extremity IED injury.*

abdominal injury were transfused more blood/blood products from time of admission to intensive care unit stay and were more likely to meet MT requirements. In combat casualties requiring major resuscitation, early use of thawed plasma in a ratio approximating 1:1 with pRBC has been shown to decrease mortality in severely injured patients.[13–16] Since coagulopathy of trauma in severely injured patients seems to start before admission, plasma-based resuscitation is thought to treat or prevent coagulopathy and shock by improving hemostasis and restoring intravascular volume and is now part of the MT protocol of CSH in OIF. Those with TA and abdominal injury received on average a pRBC:FFP ratio of 1.0 and were transfused more platelets than the comparison cohort. Aggressive use of blood/blood products in the TA cohort, also known as damage control resuscitation (DCR), is a marker of severe injury and indicates early recognition and activation of MT protocols soon after casualty arrival to trauma bay.

Both cohorts received on average a total of 2.5 L of crystal and approximately 250 mL of colloid from admission through OR and recombinant factor VIIa use was not different between cohorts. Since coagulopathy is a significant problem in the early management of the severe trauma patient who is at risk for exsanguinating hemorrhage, DCR attempts to reduce dilution of clotting factors by restricting crystalloid use and uses plasma as both a volume expander and source of clotting proteins.[15,17,18] In one study, administration of more than 3 L crystalloid or 500 mL of colloid during abdominal surgery correlated with postoperative coagulopathy.[19] Aggressive crystalloid-based resuscitation strategies are known to cause intra-abdominal hypertension and abdominal compartment syndrome as well as other complications.[20–22] DCR strategies require less intraoperative crystal and by rapidly correcting coagulopathy actually reduce overall or total blood volume transfused.[16,22,23]

Transfusion of blood products is an independent risk factor of increased length of intensive care unit stay, the development of multiple organ failure, and death.[13,24–26] The mortality of MT have been stated to be between 20% and 50%[27–31] with the majority of patients dying in 6 to 12 hours of hospital arrival.[32–33] In this study, 67 patients received MT and of those, this represented 76% of the TA group and 34% of the non-TA group. The overall incidence of MT in OIF 2007–2008 may reflect the increased incidence and destructive force of IEDs and higher MilISS of casualties presenting to CSH[5] as well as the sophisticated blood banking procedures and techniques currently in use in a war-time theater. Despite higher MilISS in the TA cohort (35 vs. 18), there was no difference in overall mortality between two groups (14% vs. 9%) or when analyzed based only on those patients in each cohort who received MT (19% vs. 20%). This marks an improvement in survival when compared with recent studies from OIF with similar ISS where mortality was 39% and 29%, respectively.[27,31] The decrease in mortality in the face of both increased severity of injury and blood/blood product usage is multifactorial and represents the procedures and mechanisms outlined above that are now in place and being used in theater and warrants further study.

Several studies have attempted to identify early predictors for MT based on presenting VS and laboratory data that are readily available at patient admission.[27,31,34,35] A casualty with both TA and abdominal injury is six times more likely to receive an MT and this injury pattern is an independent predictor of MT.

A positive correlation has been noted with increasing ISS and transfusion volume; however, ISS is difficult to calculate early after admission.[36] The ISS is obtained by squaring the three highest abbreviated injury scale (AIS) in up to three separate body regions. The AIS is scored between 1 (minor trauma) and 6 (fatal). MilISS takes into account that due to wounding patterns from fragmenting munitions, the same body regions may be multiple injured. For a combat traumatic below knee amputation, the AIS and MilISS scores are 4 and 16, respectively; for traumatic above knee amputation, 5 and 25, respectively. From data-based driven literature, an ISS score from 22 to 25 puts the combat casualty at high risk of requiring an MT.[31,36,37] Taking into account a penetrating abdominal injury, it is easy to see why this population of patients is more likely to receive an MT.

Another unique aspect of this study was evaluation of time spent on each casualty in ED and OR. Those with TA required less time in ED before moving to OR. This may be the result of not obtaining computed tomography (CT) scan on patients with obvious life-threatening injuries and moving them quickly to OR. However, CT scan has been shown to be a reliable study in fragmentation injuries in choosing nonoperative management in hemodynamically stable patients.[38] There was also a difference in time spent in OR between cohorts, this is likely a reflection of the higher MilISS in the TA cohort.

When faced with a casualty with multiple injuries and TA, the following algorithm should be applied: immediately stop hemorrhage in amputated extremity(s) with either direct

pressure at compressible site(s) or ideally with tourniquet(s). Activate MT protocol and consider alerting walking blood bank to obtain fresh WB if needed. At anytime the patient becomes hemodynamically unstable, he is taken directly to OR for exploration and definitive surgical control of hemorrhage. Focused assessment with sonography for trauma may be used in this setting to identify those with possible intra-abdominal hemorrhage and prioritize hemodynamically stable patients for further diagnostic studies such as CT scan. Based on clinical judgment and casualty's continued hemodynamic stability, CT scan may be used to determine whether fragmentation injury to the abdomen needs exploration.[38]

This study has several limitations: First, it has the inherent limitations of a retrospective study and is restricted by data that were available and collected during the study period. Second, MilISS data on host nation casualties is not available; MilISS data presented here is based solely on US military personnel as recorded in JTTR database. Third, follow-up beyond transfer from CSH was only performed on US military personnel through chart review. Once host nation casualties were discharged from CSH, no further follow-up was available. Fourth, the cohort sizes, especially the TA group, are small. Last, this is a selected group of battlefield casualties with both TA and abdominal injury requiring exploratory laparotomy. Outside of a combat environment, this data may not be transferable to a different population.

CONCLUSIONS

Traumatic amputations with penetrating abdominal injuries are associated with increased transfusions of blood products beginning at patient arrival. MTs protocols should be activated as soon as this injury is identified. The severity of the injury pattern was only manifested by an increase in the heart rate. Traumatic amputations with abdominal injury spent less time in ED and a longer time in OR, but did not suffer an increase in mortality.

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REFERENCES

1. Holcomb JB, McMullin NR, Pearse L, et al. Causes of death of U.S. Special Operation Forces in the Global War on Terror 2001–2004. *Ann Surg.* 2007;245:986–991.
2. Bellamy RF. The causes of death in conventional land warfare: implications of combat casualty research care. *Mil Med.* 1984; 149:55–62.
3. Beekley AC, Sebesata JA, Blackbourne LH, et al. Prehospital tourniquet use in operation Iraqi Freedom: effect on hemorrhage control and outcomes. *J Trauma.* 2008;64:S28–S37.
4. Kragh JF, Walters TJ, Baer DG, et al. Practical use of emergency tourniquets to stop bleeding in major limb trauma. *J Trauma.* 2008; 64:S38–S50.
5. Kelly JF, Ritenour AE, McLaughlin DF, et al. Injury Severity and cause of death from Operation Iraqi Freedom and Operation Enduring Freedom: 2003–2004 versus 2006. *J Trauma.* 2008; 64:S21–S27.
6. Baker SP, O'Neill B, Haddon W Jr, et al. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma.* 1974;14:187–196.
7. Rush RM, Stockmaster NR, Stinger HK, et al. Supporting the global war on terror: a tale of two campaigns featuring the 250th Forward Surgical Team (Airborne). *Am J Surg.* 2005;189:564–570.
8. Dorlac WC, DeBakey ME, Holcomb JB, et al. Mortality from isolated civilian penetrating extremity injury. *J Trauma.* 2005; 59:217–222.
9. Costello CN, Eastridge BJ, Holcomb JB, et al. Changing the Holy Grail of Evacuation: The Golden Hour. Unpublished.
10. Peoples GE, Gerlinger T, Craig R, et al. Combat casualties in Afghanistan cared for by a single forward surgical team during the initial phases of Operation Enduring Freedom. *Mil Med.* 2005; 170:462–468.
11. Mabry RL, Holcomb JB, Baker AM, et al. United States Ranger in Somalia: an analysis of combat casualties on an urban battlefield. *J Trauma.* 2000;49:512–528.
12. Holcomb JB. Fluid resuscitation in modern combat casualty care: lessons learned from Somalia. *J Trauma.* 2003;54:S221–S225.
13. Spinella PC, Perkins JG, Grathwohl KW, et al. Effect of plasma and red cell transfusions on survival in patients with combat related traumatic injuries. *J Trauma.* 2008;64:S69–S78.
14. Gonzalez EA, Moore FA, Holcomb JB, et al. Fresh frozen plasma should be given earlier to patients requiring massive transfusion. *J Trauma.* 2007;62:112–119.
15. Ketchum L, Hess JR, Hiippala S. Indications for early fresh frozen plasma, cryoprecipitate, and platelet transfusion in trauma. *J Trauma.* 2006;60:S51–S58.
16. Cotton BA, Gunter OL, Isbell J, et al. Damage control hematology: the impact of trauma exsanguination protocol on survival and blood product utilization. *J Trauma.* 2008;64:1177–1183.
17. Holcomb JB, Hoyt D, Hess JR. Damage control resuscitation: the need for specific blood products to treat the coagulopathy of trauma. *Transfusion.* 2006;46:685–686.
18. Hirshberg A, Dugas M, Banez EI, et al. Minimizing dilutional coagulopathy in exsanguinating hemorrhage: a computer simulation. *J Trauma.* 2003;54:454–463.
19. Barak M, Rudin M, Vofsi O, et al. Fluid administration during abdominal surgery influences on coagulation in the postoperative period. *Curr Surg.* 2004;61:459–462.
20. Balogh Z, McKinley B, Cocanour CS, et al. Supra-normal trauma resuscitation causes more cases of abdominal compartment syndrome. *Arch Surg.* 2003;138:637–643.
21. Maxwell RA, Fabian TC, Croce MA, et al. Secondary abdominal compartment syndrome: an underappreciated manifestation of severe hemorrhagic shock. *J Trauma.* 1999;47:995–999.
22. Cotton BA, Guy JS, Morris JA, et al. The cellular, metabolic, and systemic consequences of aggressive fluid resuscitation strategies. *Shock.* 2006;26:115–121.
23. Holcomb JB, Jenkins D, Rhee P, et al. Damage control resuscitation: directly addressing the early coagulopathy of trauma. *J Trauma.* 2007;62:307–310.
24. Ciesla DJ, Moore EE, Johnson JL, et al. A 12-year prospective study of postinjury multiple organ failure: has anything changed? *Arch Surg.* 2005;140:432–438.
25. Malone DL, Dunne J, Tracy JK, et al. Blood transfusion, independent of shock severity, is associated with worse outcome in trauma. *J Trauma.* 2003;54:898–905.
26. Moore FA, Moore EE, Sauaia A. Blood transfusion. An independent risk factor for postinjury multiple organ failure. *Arch Surg.* 1997;132:620–624.

27. Schreiber MA, Perkins J, Kiraly L, et al. Early predictors of massive transfusions in combat casualties. *J Am Coll Surg*. 2007;205:541–545.
28. Malone DL, Holcomb JB, Fingerhut A. Massive transfusion practices around the globe and a suggestions for a common massive transfusion protocol. *J Trauma*. 200;60:S91–S96.
29. Huber-Wagner S, Qvick M, Mussack T, et al. Massive blood transfusion and outcome in 1062 polytrauma patients: a prospective study based on the Trauma Registry of the German Trauma Society. *Vox Sang*. 2007;92:69–78.
30. Sauaia A, Moore FA, Moore EE, et al. Epidemiology of trauma deaths: a reassessment. *J Trauma.* 1995;38:185–193.
31. McLaughlin DF, Niles SE, Salinas J, et al. A predictive model for massive transfusions in combat casualty patients. *J Trauma*. 2008; 64:S57–S63.
32. Peng R, Chang C, Gilmore D, et al. Epidemiology of immediate and early trauma deaths at an urban level I trauma center. *Am Surg.* 1998;64:950–954.
33. Demetriades D, Murray J, Charalambides K, et al. Trauma fatalities: time and location of hospital deaths. *J Am Coll Surg*. 2004;198:20–26.
34. Cancio LC, Wade CE, West SA, et al. Prediction of mortality and need for massive transfusion in casualties arriving at combat support hospital in Iraq. *J Trauma*. 2008;64:S51–S56.
35. Eastridge BJ, Owsley J, Sebesta J, et al. Admission physiology criteria after injury on the battlefield predict medical resource utilization and patient mortality. *J Trauma.* 2006;61:820–823.
36. Eastridge BJ, Malone D, Holcomb JB. Early predictors of transfusion and mortality after injury: a review of the database literature. *J Trauma.* 2006;60:S20–S25.
37. Como JJ, Dutton RP, Scalea TM, et al. Blood transfusion rates in the care of acute trauma. *Transfusion.* 2004;44:809–813.
38. Beekley AC, Blackbourne LH, Sebesta JA, et al. Selective non-operative management of penetrating torso injury from combat fragmentation wounds. *J Trauma.* 2008;64:S108–S117.